

We claim,

1. A vertebral disc endoprosthesis, comprising a resilient body formed of materials varying in stiffness from a relatively stiff exterior portion to a relatively supple central portion; and concaval-convex elements at least partly surrounding the resilient body between adjacent vertebral bodies for retaining the resilient body between adjacent vertebral bodies in a patient's spine, and wherein said concaval-convex elements each comprise generally L-shaped supports, each support having a first concaval-convex leg, the first leg having an outer convex surface for engaging adjacent bone and a corresponding inner concave surface for retaining the resilient body, each support further having a second leg extending generally perpendicularly to the first leg and adapted for affixation to adjacent bone structure.
2. A vertebral disc endoprosthesis according to Claim 1 wherein said resilient body comprises an annular gasket and a nuclear central portion.
3. A vertebral disc endoprosthesis according to Claim 1 further comprising cannulated screw means for attaching the concaval-convex element supports to adjacent bone structure.
4. A vertebral disc endoprosthesis according to Claim 3 wherein said cannulated screw means comprises a screw, and a screw anchor seatable within bone structure and adapted to threadably receive the screw.
5. A vertebral disc endoprosthesis according to Claim 1 further comprising a seal member attached to the concaval-convex elements and surrounding said resilient body.
6. A vertebral disc endoprosthesis according to Claim 5 wherein said seal member comprises a flexible shell material having a multiplicity of pores, the pores being from about 5 microns to about 60 microns in size.
7. A vertebral disc endoprosthesis according to Claim 6 further including sealing means applied to said flexible sheet material to render said flexible sheet material substantially impervious to the passage of any fluid.

8. A vertebral disc endoprosthesis according to Claim 5 wherein said concaval-convex elements and said seal member collectively surround said resilient body with a watertight seal.

9. A vertebral disc endoprosthesis according to Claim 2 wherein said annular gasket is relatively stiff and said nuclear central portion is relatively supple.

10. A vertebral disc endoprosthesis according to Claim 1 wherein said concaval-convex elements are formed of a biocompatible metal.

11. A vertebral disc endoprosthesis according to Claim 1 wherein said concaval-convex elements are formed of a metal containing titanium.

12. A vertebral disc endoprosthesis according to Claim 1 wherein said concaval-convex elements are formed of a metal containing chromium cobalt.

13. A vertebral disc endoprosthesis according to Claim 10 wherein said concaval-convex elements are each partly defined by exterior surfaces, and wherein the endoprosthesis further includes metal beading on at least part of the exterior concaval-convex element surfaces for encouraging bonding between bone and said exterior concaval-convex element surfaces.

14. A vertebral disc endoprosthesis according to Claim 1 wherein said concaval-convex elements are provided with roughened outer surfaces to encourage positive bonding of bone to said concaval-convex element surfaces.

15. A vertebral disc endoprosthesis according to Claim 1 wherein said concaval-convex elements are formed of a non-oncogenic material.

16. A vertebral endoprosthesis comprising an integral disc unit, said unit including a pair of confronting L-shaped supports having concaval-convex shapes in given legs, a resilient body interposed between the supports, and a flexible seal extending from one support to the other and sealing the resilient body within the supports inside a substantially watertight compartment.

17. A vertebral endoprosthesis according to Claim 16 further comprising a plurality of said integral disc units.

18. A vertebral disc endoprosthesis comprising a resilient nucleus, rigid concaval-convex elements at least partly surrounding the nucleus, an annular gasket ring surrounding the nucleus, and a seal member formed of flexible material and attached to the concaval-convex elements and surrounding the nucleus and the annular gasket ring.

19. A vertebral disc endoprosthesis according to Claim 18 wherein said concaval-convex elements each comprise generally L-shaped supports, each support having a first concaval-convex leg, the first leg having an outer convex surface for engaging adjacent bone and a corresponding inner concave surface for retaining the nucleus, each support further having a second leg extending generally perpendicularly to the first leg and adapted for affixation to adjacent bone structure.

20. A vertebral disc endoprosthesis, according to Claim 19 further including screw means adapted for connection to said legs and for affixation in a generally radial direction in adjacent generally cylindrical bone vertebrae.

21. A vertebral disc endoprosthesis according to Claim 18 further including means affixed to the concaval-convex elements for encouraging bone growth partially upon and bone bonding with said concaval-convex elements.

22. A vertebral disc endoprosthesis according to Claim 18 further including means for interconnecting one of said concaval-convex elements to a concaval-convex element of another vertebral disc endoprosthesis, thereby permitting the replacement of several natural vertebral discs.

23. A method of endoprosthetic discectomy surgery comprising the steps of receiving information about the size, shape and nature of a patient's damaged natural spinal vertebral bodies and discs from radiographs, CT and/or MRI scans or other imaging devices specifically determining the anterior-posterior and lateral dimensions of each involved vertebral body, the vertical height of the anterior aspect of each involved vertebral and/or proximate vertebral body, and the vertical height of the mid-portion of the involved and proximate normal intervertebral disc spaces, thereafter constructing one or more prosthetic vertebral body units and prosthetic

disc units in conformity with the received information, each prosthetic disc unit including confronting L-shaped concaval-convex elements and a resilient body interposed between the concaval-convex elements; and an endoprosthetic vertebral body interposed between and engaging the adjacent disc units; and thereafter implanting the completed and conformed construction in the patient's spine.

2 24. A method according to Claim *23* including the step of constructing a plurality of prosthetic disc units and further including the step of attaching the disc units to an endoprosthetic vertebral body prior to the step of supplying the assembly to the surgeon.

3 25. A method according to Claim *23* further including the steps of surgically milling spinal bone surfaces with concave surfaces to receive confronting convex surfaces of the concaval-convex elements, and installing at least one disc unit having concaval-convex elements with said convex surfaces in the patient's spine.

Dub C17 26. A method of surgery comprising the steps of removing a vertebral disc from a patient's spine, forming holes at precisely predetermined locations in bone structure adjacent the location of the removed disc, tapping the holes to form a female thread in each hole, and threadably implanting an anchor into each tapped hole, thereby creating an imaginary platform of reference points located precisely with respect to the patient's spine, forming concave surfaces in adjacent spinal bone, and inserting between the formed bone surfaces a vertebral disc endoprosthesis including confronting concaval-convex supports, each support having an exterior convex surface adapted to mate with the adjacent formed concave spinal bone surface, the endoprosthesis further including a resilient body element interposed between the concaval-convex supports, and thereafter affixing the concaval-convex supports to the adjacent bone.

5 27. A method of surgery according to Claim *26* further including the step of temporarily locating a bone surface milling jig at the site of the removed vertebral disc by means of said anchors prior to implanting said disc endoprosthesis.

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28. A method of surgery according to Claim 26 further including the steps of attaching a screw to each concaval-convex support and screwing said screw into an implanted anchor.

29. A method of surgery according to Claim 26 further comprising the steps of identifying a damaged resilient nucleus body element or annular gasket in an implanted endoprosthesis, removing said damaged nucleus body element or annular gasket from the endoprosthesis and inserting a new, undamaged nucleus body element or annular gasket into the endoprosthesis without removing the concaval-convex supports from the patient's spine.

30. A method of spinal surgery comprising the steps of forming mounting holes in one or more vertebral bodies of a patient's spine; utilizing said mounting holes to mount a bone mill on a patient's spine; milling confronting bone surfaces on and in the patient's spine to a predetermined surface shape; removing said mill; and thereafter mounting a vertebral disc endoprosthesis having a predetermined outer surface shape by means of the original mounting holes so that outer surfaces of the vertebral disc endoprosthesis mate precisely with the previously milled bone surfaces.

31. A vertebral disc endoprosthesis comprising a resilient nucleus, first and second rigid concaval-convex elements at least partly surrounding the nucleus, first and second legs formed, respectively, with the first and second rigid concaval-convex elements, first and second means for affixing the respective legs to vertebral bodies adjacent the concaval-convex elements and nucleus, and longitudinal ligament prosthesis means extending between the legs of the first and second concaval-convex elements to inhibit undesirable motion of the vertebral bodies relative to one another.

32. A vertebral disc endoprosthesis comprising a rounded, resilient nucleus body convex on all surfaces and concaval-convex elements, each concaval-convex element being of relatively constant cross-sectional thickness and having an outer convex surface for engaging adjacent bone structure which has been milled to mate with the concaval-convex element outer

convex surface, and a corresponding inner concave surface for engaging the rounded resilient body.

33. A vertebral disc endoprosthesis according to Claim 32 wherein said resilient nucleus body comprises a relatively resilient central body and a relatively stiff gasket surrounding a circumference of the central body, the resilient nucleus body snugly engaging the adjacent, mating concave surfaces of the concaval-convex elements.

34. A vertebral disc endoprosthesis according to Claim 33 wherein the concaval-convex elements do not engage one another.

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35. A method of end prosthetic discectomy surgery comprising the steps of receiving information about the size, shape and nature of a patient's involved and proximate normal natural spinal vertebral bodies and natural spinal vertebral discs from known imaging devices, thereafter constructing at least one vertebral disc endoprosthesis comprising a resilient disc body and concaval-convex elements at least partly surrounding the resilient disc body, removing at least the involved, natural spinal discs from the patient's spine and thereafter implanting the vertebral disc endoprosthesis in the patient's spine.

36. The vertebral disc endoprosthesis according to Claim 1 wherein each concaval-convex element is provided with a respective groove.

37. The vertebral disc endoprosthesis according to Claim 36 further comprising a seal member including beaded edges, the seal member attached to the concaval-convex elements and surrounding said resilient body.

38. The vertebral disc endoprosthesis according to Claim 37 further comprising retainer means for retaining the seal member against said grooves, the retainer means cooperating with the beaded edges and the grooves to form a watertight seal.

39. The vertebral disc endoprosthesis according to Claim 38 wherein the retainer means can be in one of the following forms: a biocompatible monofilament metal wire, a synthetic polymer band or a braided wire cable.

40. The vertebral disc endoprosthesis according to Claim 39 wherein the biocompatible monofilament metal wire is formed of stainless steel or titanium.

41. The vertebral disc endoprosthesis according to Claim 38 further comprising a crimping means for crimping the retainer means about the seal member.

42. The vertebral disc endoprosthesis according to Claim 1 wherein each support includes a groove about its circumference, the groove encircling the periphery of the first leg.

43. The vertebral endoprosthesis according to Claim 16 wherein each support includes a groove about its periphery and wherein the seal includes beaded edges.

44. The vertebral endoprosthesis according to Claim 43 further comprising retainer means for retaining the seal against said grooves, the retainer means cooperating with the beaded edges and the grooves to form a watertight seal.

45. The vertebral endoprosthesis according to Claim 44 wherein the retainer means can be in one of the following forms: a biocompatible monofilament metal wire, a synthetic polymer band or a braided wire cable.

46. The vertebral endoprosthesis according to Claim 45 wherein the biocompatible monofilament metal wire is formed of stainless steel or titanium.

47. The vertebral endoprosthesis according to Claim 44 further comprising a crimping means for crimping the retainer means about the seal.

48. The vertebral disc endoprosthesis according to Claim 18 wherein each element includes a respective groove and wherein the seal member includes beaded edges.

49. The vertebral disc endoprosthesis according to Claim 48 further comprising retainer means for retaining the seal member against said grooves, the retainer means cooperating with the beaded edges and the grooves to form a watertight seal.

50. The vertebral disc endoprosthesis according to Claim 49 wherein the retainer means can be in one of the following forms: a biocompatible monofilament metal wire, a synthetic polymer band or a braided wire cable.

51. The vertebral disc endoprosthesis according to claim 50 wherein the biocompatible monofilament metal wire is formed of stainless steel or titanium.

52. The vertebral disc endoprosthesis according to claim 49 further comprising a crimping means for crimping the retainer means about the seal member.

53. The vertebral disc endoprosthesis according to Claim 19 wherein each support includes a groove about its circumference.